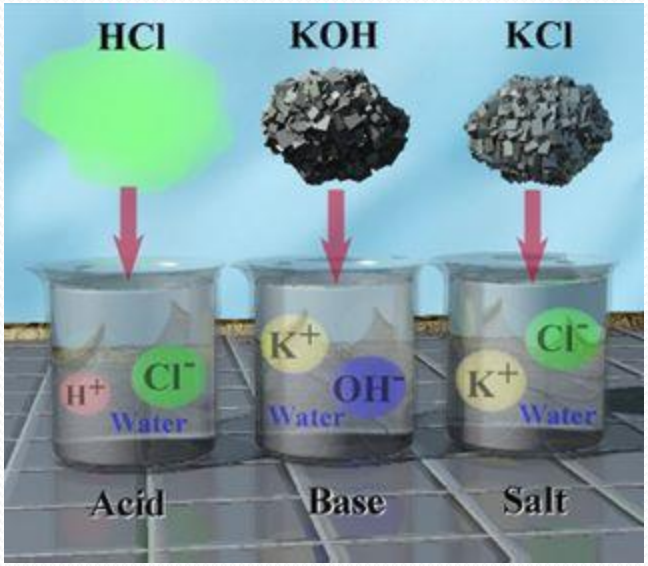
Acid-Base Properties of Salts

What is a salt?

- Another name for an ionic compound
- Created in acid-base reaction
- Assumed to break into its ions when dissolved in water
- Can be classified as basic, acidic, or neutral depending on nature of the salt



Classifications of Salts

- Salts that consist of the cations of strong bases and the anions of strong acids have no effect on $[H^+]$ when dissolved in water and are considered neutral
  - Example: KCl, NaCl, $NaNO_3$, KNO_3
    - K^+ and Na^+ from KOH and NaOH
    - Cl^- and NO_3^- from HCl and HNO_3
- Salts who cations are from strong bases and whose anions are the conjugate bases of weak acids will be basic
  - Example: $NaC_2H_3O_2$, KCN, NaF
    - $C_2H_3O_2^-$, CN^-, and F^- from $HC_2H_3O_2$, HCN, and HF (all weak acids)
    - Na^+ and K^+ from NaOH and KOH

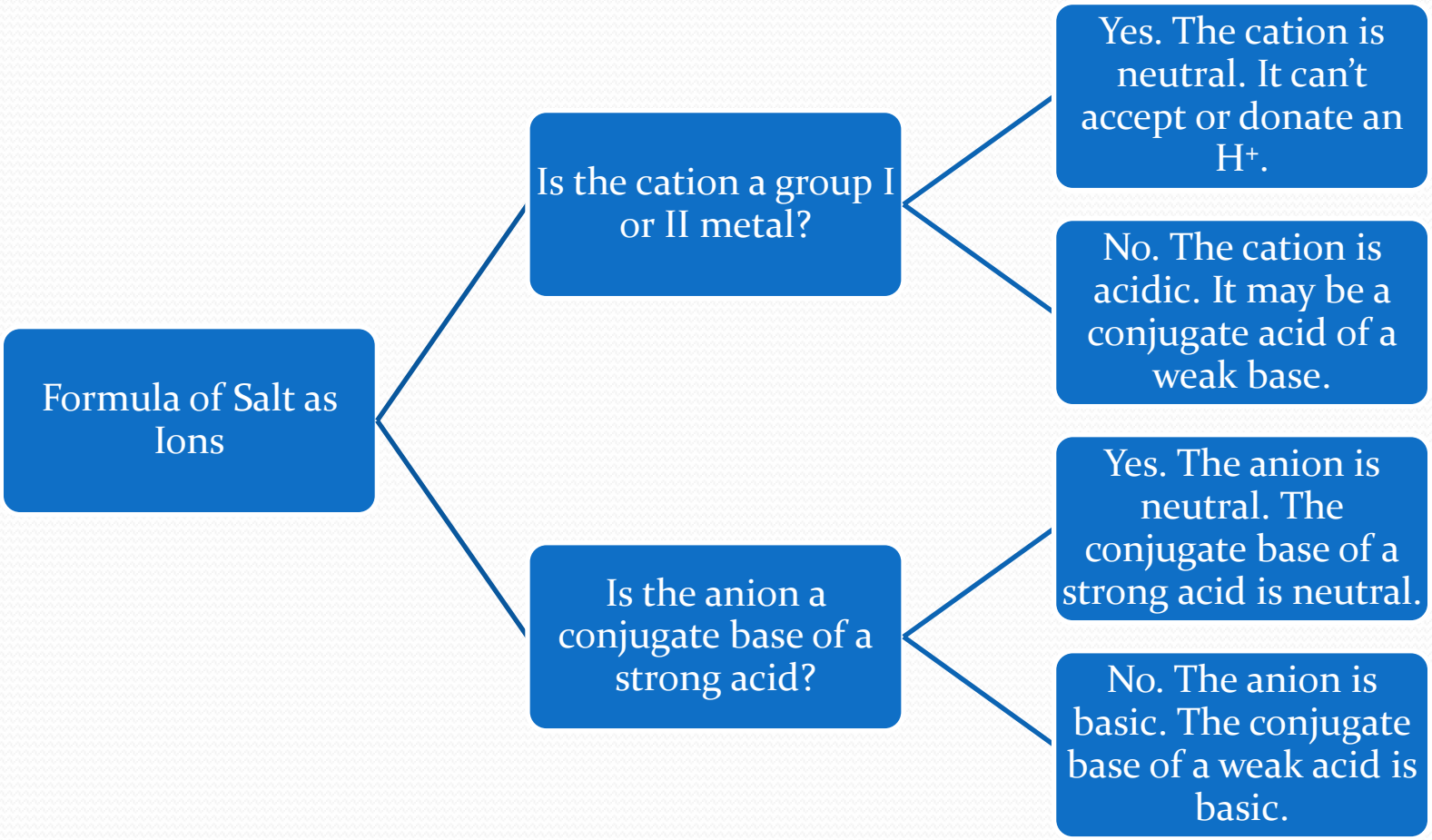
Classification of Salts

- Salts in which the anion is from a strong acid and the cation is the conjugate acid of a weak base will be acidic
  - Example: NH_4Cl, NH_4NO_3
    - NH_4^+ from NH_3 (weak base)
    - Cl^- and NO_3^- from HCl and HNO_3
- Salts whose cations are highly charged metal ion and the anions are from strong acid will be acidic
  - Example: $Al(NO_3)_3$, $FeCl_3$
    - Al^{3+} and Fe^{3+} are both highly charged metal ions
    - NO_3^- and Cl^- are from HNO_3 and HCl

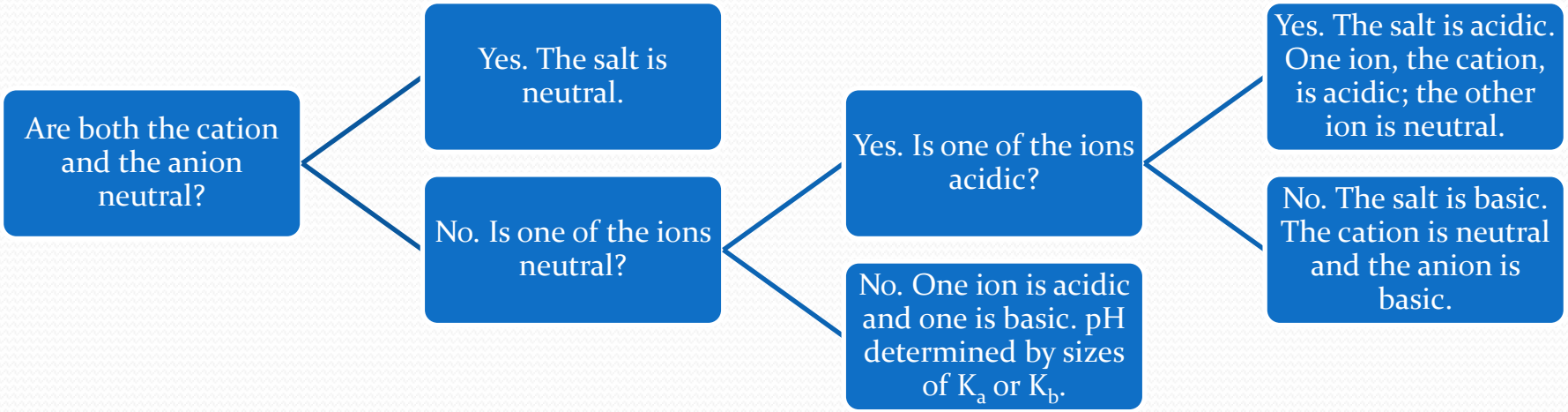
Classification of Salts

- Salts whose cation is a conjugate acid of weak base and whose anion is a conjugate base of a weak acid depends on K_a and K_b values
  - Acidic if $K_a > K_b$
  - Basic if $K_b > K_a$
  - Neutral $K_a = K_b$
  - Example: $NH_4C_2H_3O_2$, NH_4CN
    - NH_4^+ is from NH_3 (weak base)
    - $C_2H_3O_2^-$ and CN^- from $HC_2H_3O_2$ and HCN (weak acids)

Predicting pH of Salts



Predicting pH of Salts



Example

- Determine whether an aqueous solution of $KC_2H_3O_2$ is acidic, basic, or neutral.
- Split into ions: K^+ and $C_2H_3O_2^-$
- K^+ is neutral because it is a group I metal
- $C_2H_3O_2^-$ is basic because it is not a conjugate base of a strong acid but rather a conjugate base of a weak acid
- Therefore, $KC_2H_3O_2$ is a basic salt

Calculating pH of Salts

- Decide if salt is basic, acidic , or neutral
- If salt is basic, then its anion is the conjugate base of a weak acid
  - Anion will undergo hydrolysis
- If salt is acid, then its cation is the conjugate acid of a weak base
  - Cation will undergo hydrolysis

Example

- Determine the pH of a 0.100 M aqueous solution of NaCN. The K_a is 5.8×10^{-10}.
- Na^+ is from a strong base so it's neutral
- CN^- is the conjugate base of a weak acid so it's basic
- Anion undergoes hydrolysis:

$$CN^- (aq) + H_2O (l) \leftrightarrow HCN (aq) + OH^- (aq)$$

- Need K_b so it can be calculated from K_a

$$K_b = \frac{1.0\ x\ 10^{-14}}{K_a} = \frac{1.0\ x\ 10^{-14}}{5.8\ x\ 10^{-10}} = 1.7\ x\ 10^{-5}$$

Example

- Set up ICE table

	CN^- (aq)	H_2O (l)	HCN (aq)	OH^- (aq)
I	0.100	----------	0	0
C	- x	----------	+ x	+ x
E	0.100 – x	----------	x	x

- Since K_b is really small (10^{-5}) than 0.100 – x can be approximated as 0.100
- Solve for x

$$K_b = \frac{[OH^-][HCN]}{[CN^-]} \rightarrow 1.7x10^{-5} = \frac{x^2}{0.100}$$

$$x = [OH^-] = 1.3\ x\ 10^{-3}\ M$$

Example

- Solve for pOH and then pH

$$pOH = -\log(1.3\ x\ 10^{-5}) = 2.89$$

$$pH = 14.00 - pOH = 14.00 - 2.89 = 11.11$$